NASnews

Supercomputing 1997 Special Section

NASA Centers Collaborate On SC97 Demonstrations

Five NASA facilities--Ames Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory (JPL), Langley Research Center (LaRC), and Lewis Research Center (LeRC)--will demonstrate NASA technology and research from one large booth at SC97, November 15-21 in San Jose, CA.

The combined exhibit--a first for NASA--was coordinated over the last several months by personnel at all five centers, and is one of the largest research booths at the show. The booth will feature the Stereo Visualization Theater (SVT), a 3D animation highlighting NASA research from all five centers. Developed by the NAS Systems Division's multimedia team, the SVT brings together graphics, digital audio, and stereo projection in a presentation system that delivers a degree of resolution not possible with conventional video tape or multimedia. Other demonstrations in the booth include a real-time experimental network, with live links to weather stations at the San Francisco International Airport and a tie-in to NASA windtunnel and computational data on the Whitney cluster, also made up of Pentium Pros, from Ames. In addition, workstations and monitors around the booth will host demonstrations of NASA's supercomputing-related work and show off NASA-developed software and hardware. NASA-related research will also be featured in the technical portions of the conference, with researchers presenting papers and leading workshops

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Numerical Propulsion System Simulation Video

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Stereo Theater Shows NASA Research Data in 3D

The NASA booth at SC97 will showcase the Stereo Visualization Theater (SVT). Coordinated by the NAS Systems Division's multimedia team, this year's SVT looks at recent research completed at NASA centers around the country. Datasets from several NASA sites feature different areas of research, from aerospace to stratospheric dynamics. These datasets include:

· Flow traces through an axial-symmetric CFD analysis of a full-engine simulation. The engine is the "E-cubed" (Energy Efficient Engine) that NASA helped develop in the 1980s. This full-engine simulation demonstrates how all the parts of the engine interact. The simulation is one of many created at the Numerical Propulsion System Simulator at NASA Lewis Research Center.

· 3D rendering of methane in the stratosphere. Data retrieved from the NASA Upper Atmosphere Research Satellite (UARS) was assimilated into a complete gridded dataset using the Kalman filter, developed at NASA's Data Assimilation Office at Goddard Space Flight Center. This is one of the first stratospheric datasets formed using Four Dimensional Data Assimilation, which uses the Kalman filter method. It is also one of the first renderings of 3D dynamics in the stratosphere. The most important aspect of the Kalman filter is its ability to form complete datasets for purposes of climate research and visualization from the scattered data from a satellite.

· Unsteady visualization of particle streaks in a cavity housing a 2.5 meter (8 ft.) aperture Cassegrain telescope in SOFIA (the Stratospheric Observatory For Infrared Astronomy), under development at Ames Research Center. This Boeing 747 aircraft will fly in the Earth's stratosphere, at around 13 km (44,000 ft.). Using windtunnel and computational fluid dynamics data, the researchers seek to understand and resolve issues arising from the location of the telescope in an open hole in the aircraft during flight. The simulation solves unsteady Navier-

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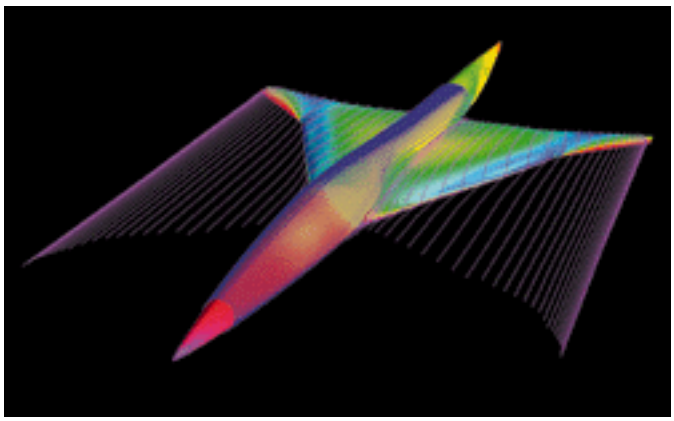
Stokes equations on an overset grid framework using the OVERFLOW flow solver. The visualization uses UFAT, the Unsteady Flow Analysis Toolkit, developed at Ames.



· Simulation of airflow around a design for a high-speed civil transport aircraft. The wing and body are colored according to the local surface pressure on the vehicle at supersonic cruise conditions. The streamlined nature of this configuration is exhibited by the relatively small disturbances in the particle traces displayed.

· Simulation of the reaction between two moleculesa benzyne molecule and a carbon nanotube (a hollow tube with one-atom-thick sides). The theoretical molecule created by this simulated reaction has yet to be manufactured, but calculations show that it should be viable. A carefully controlled series of these reactions could make atomically precise gears. The animation show that when one such gear is forced to turn, interatomic and intermolecular forces cause a second gear to turn. Microscopic gears are a small step toward creating the manufacturing systems of the future, which may revolutionize medicine, materials science, and space travel.

Simulations such as these already stretch NASA's current computing resources to the limit. The SVT presentation also introduces NASA's Information Power Grid (IPG), an initiative to create a nationwide computational capability. The IPG will seamlessly intergrate high-performance computing, data storage, and visualization resources around the country into a unified, interdisciplinary, problem-solving environment.

The SVT itself is intended for high-quality presentation to multiple participants. It can be used for peer reviews, scientific visualization presentations, and stereoscopic visualization of scientific data. The theater runs on a Silicon Graphics Inc. Onyx RE2, and uses an Elecrohome Marquee 9500 data projector, a Stereo Graphics polarizing filter, and custom presentation software. Through the use of polarized

glasses, two different images are displayed on the screen simultaneously, but each eye sees only one of the imagescreating the illusion of depth and three dimensions.

HPCC Learning Technologies Project

The NASA High Performance Computing and Communications (HPCC) Program's Learning Technologies Project (LTP) uses emerging technologies to inform the educational community about science. LTP is managed out of Ames Research Center and involves ten NASA centers. The project was formed from the educational component of the HPCC Program.

The challenge in adapting scientific tools and information to the classroom is that the typical school infrastructure does not currently support the requirements of these applications. However, using emerging technologies and proven approaches such as data compression and data streaming to overcome bandwidth limitations, LTP provides a workable model for the classroom. At SC97, the LTP demonstration will include:

· Distance learning through low-bandwidth desktop teleconferencing

· Web-based applications for applying remotely sensed data to the classroom

· Digital Library Technologies, including the Alexandria Digital Library, where users can browse library holdings electronically and search by spatial or temporal location or by metadata content.

· Low-cost networking solutions that allow schools to connect many campuses through a single, standard phone line.

Virtual Laboratory for Remote Research

Virtual Laboratory, or VLAB, a project to develop the technology and

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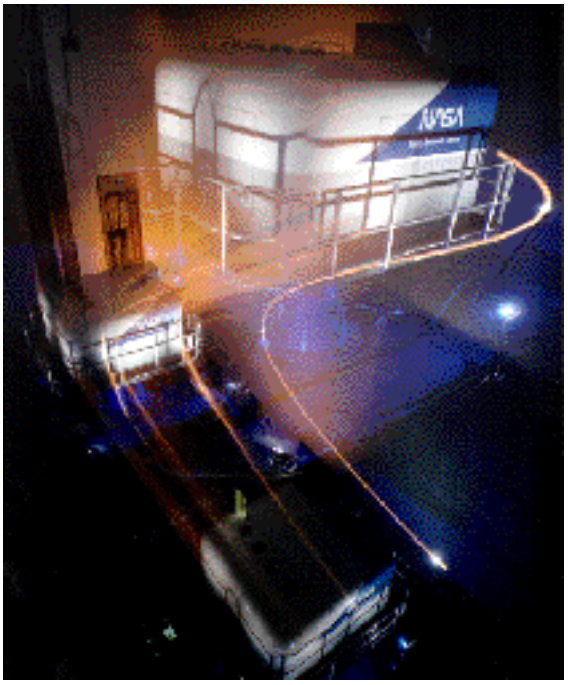
methodology for remote access to a research facility, employs an interactive, multi-user, virtual reality interface. The emphasis is on the user's perspectivea virtual environment in which the user interactively defines the specific data and display configuration that will afford the most productive participation in the experiment.

VLAB will be demonstrated via a real-time connection to the Vertical Motion Simulator Facility (VMS) at Ames Research Center, supplied by the NASA Research and Educational Network (NREN). Individuals at SC97 will interact with ongoing flight simulations at the VMS.



Although VLAB's first application is in flight simulation, the concepts being developed for applicability to any remote-access, virtual-control-room situation, such as wind tunnels, flight test facilities, and multiple, interoperable labs.

VLAB also allows managers to participate in demonstrations from diverse functional areas such as program planning, flight operations, and system design, indicating that the VLAB concept could "play" in Integrated Design System, remote flight test, and in a myriad of other programs.

Experimental Networks for SC97

The NAS Systems Division will be working closely with pathfinding government and commercial projects to push the state-of-the-art in high-performance computer networks. NAS will demonstrate experimental networking that features quality-of-service (QOS) for high-performance networks. For this demo, NAS will work with the Development Aeronautics Revolutionizing Windtunnels and Intelligent systems for NASA (DARWIN) and Surface Movement Advisor (SMA) projects at Ames, and with Paramount Studios in Hollywood.

The network will connect the San Jose Convention Center to DARWIN

facilities throughout Ames, providing access to DARWIN windtunnel and computational datasets. To show SMA, the network will connect to the control towers at Moffett Field, San Francisco Airport, and the Atlanta Hartsfield Airport, to provide real-time updates of weather conditions, ground control, and flight status at each airport.

The network will demonstrate a distributed video and film editing environment for Hollywood. This Virtual Studio will combine high-performance video sources, editing, and displays on the show floor, and demonstrate how networks and network QOS can be used to enable real-time distance-independent video production, using content developed on the show floor combined with video from Hollywood and NASA. More information is available on the Network Research Group's web site.

Large-scale Computing With Commodity Components

The NAS Systems Division will demonstrate a new prototype, called "Whitney," built to help researchers design extremely scalable systems software for future petaflop-class systems. Whitney, a large-scale computing testbed, is built entirely from commodity components. Its main goals are to allow design of extremely scalable systems software, investigation of cost-effective supercomputing, and evaluation of commodity components.

At the conference, the prototype (with 128 megabytes of RAM per processor) will run MPI jobs using the MPICH MPI library. The system will use the Portable Batch System (PBS) for job scheduling.

The Whitney project is one of the first effort to build a large-scale system from commodity parts. Designed to support a traditional supercomputer workload (many users, many jobs), it will provide a testbed for scalable systems software. The prototype will initially be used both as a computing platform and as a testbed to study various cost/performance tradeoffs in larger systems.

NAS Systems Division Highlights Software

The NAS Systems Division will demonstrate several software packages, including:

· The Automated Instrumentation and Monitoring System (AIMS), a software toolkit developed at Ames Research Center over the past six years. AIMS allows users to tune their parallel programs by revealing execution bottlenecks. Its easy-to-use graphical interface enables performance data to be collected and analyzed automatically. The Department of Commerce recently allowed worldwide distribution of AIMS, without restriction or copyright. The demonstration will highlight basic features of AIMS, including a new feature utilizing statistics to shorten trace files.

· The NAS Trace Visualizer (NTV), a tool used to visualize execution traces from message-passing systems. NTV is designed to be ported easily to different trace formats, and supports traces produced on the IBM SP2 using the native IBM Message Passing Interface trace, as well as trace files produced using AIMS . A distinctive characteristic of NTV is that it uses static displays rather than time-varying displays. This, in combination with mouse-controlled zooming, gives users the ability to see a global view of the execution and a focused view of details. The principal display is a time-line that is color coded to show status for each processor. Two types of summary (profiling) displays are also produced. One allocates information by processor (for example, the time the processor was blocked sending), the other allocates information by function (for example, the time a function was blocked sending).

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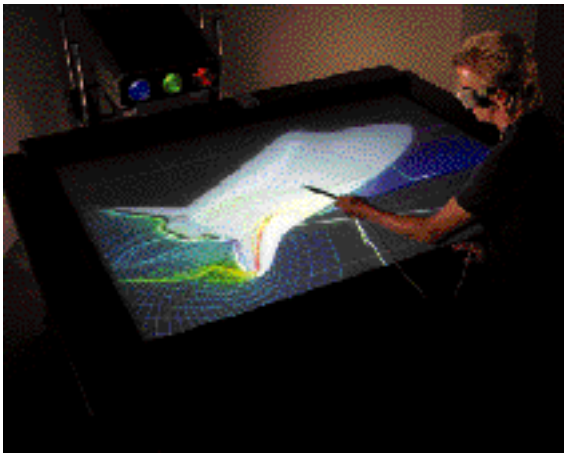
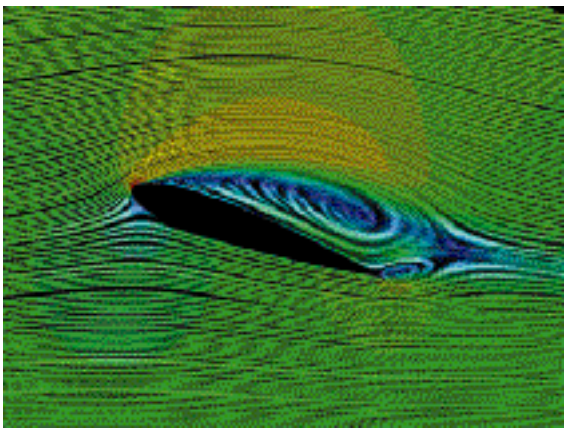


· Virtual Wind Tunnel (VWT) and Mouse-based Virtual Wind Tunnel, software that applies virtual reality interface technology to the visualization of precomputed computational fluid dynamics simulations. A three-dimensional display gives the user superior perception of the complicated structures that arise in fluid flow. Interactive visualization techniques allow intuitive and rapid exploration of flow phenomena, providing rapid understanding of complex flows. The VWT is currently being used on a trial basis at Boeing Computer Services, Rockwell Science Center, and NASA Langley Research Center. The demo will show interactive streamlines of airflow around an aircraft generated using the VWT. The Mouse-based Virtual Wind Tunnel brings most of the intuitive three-dimensional interaction capabilities of the VWT to those with SGI workstations.

· The Portable Parallel/Distributed Debugger (p2d2), a debugging system for parallel and distributed programs that was developed for the dual purposes of providing a consistent user interface across all platforms (reducing the amount of effort required to learn how to use a debugger) and providing user interface features that scale to a large number of processes. A recent update allows the debugger to support breakpoints inserted in a timeline, and makes it possible to have an "undo" operation. The demonstration will show how execution trace information can be used to understand what has happened during the course of a computation. The demo will also highlight p2d2's basic capabilities, its accommodation for multidisciplinary codes, and the power of its scalable user interface.



· Unsteady Flow Line Integral Convolution (UFLIC), a software package that supports flow visualization of CFD aerodynamic simulations. The demonstration of this software will feature interactive surface flow visualization applied to several aircraft, animation of

surface flow patterns from time-dependent flow fields, and a demonstration of automatic flow feature detections from the surface flow patterns.

· PMPIO, the Portable Message-Passing I/O library, a parallel I/O library based on a subset of the I/O chapter of the recently completed MPI-2 standard. PMPIO is one of the first implementations of a standard parallel I/O library. With a standard message-passing and I/O library, it is now possible to create complete applications that are portable across most parallel systems. PMPIO also provides improved performance for scientific applications that utilize complex data layouts through a specialized buffering technique.

PMPIO completes the infrastructure for developing portable, high-performance parallel applications by providing an open standard I/O interface. Target applications are scientific parallel codes based on the MPI message-passing standard. PMPIO runs on most parallel systems that can run the MPICH MPI library, developed by Argonne National Laboratory and Mississippi State University. Examples include the IBM SP2 and the Intel Paragon, as well as IBM, Silicon Graphics Inc., and Sun Microsystems workstation clusters.

· The Multi-Source Visualization project tools to support the display and analysis of data from heterogeneous sources. Two software packages will be demonstrated: exVis and VISOR. exVis is designed to support visualization and analysis of data collected with unusual instruments during wind tunnel experiments. The common element in this data is that it is acquired using image-based systems. exVis allows two-dimensional display and interactive query of the data. The software allows display with user-controlled color mappings and includes a tool for selecting a subset of data to plot in the form experimental researchers are familiar with. exVis is available through the NAS Software Archive.

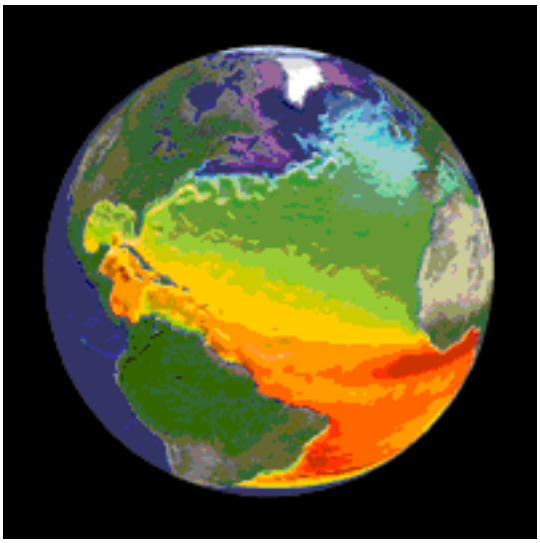
VISOR (Visual Integration of Simulated and Observed Results) is a program designed to display data selected from several sources (computational and experimental) in a single three-dimensional environment. In this way, data acquired in separate tests, from different types of sensors or simulation results, can be displayed together to allow comparisons and improve understanding. This demo will show a pre-release version of VISOR.

· Automatic Flow Feature Detection software. Feature detection

algorithms are being developed that automatically analyze gigabyte datasets and extract important flow features, such as vortex cores and separation lines. This software was developed in response to NASA's industrial partners, who requested tools that would reduce the analysis time of large computational fluid dynamics simulations. The demonstration shows vortex cores, separation and re-attachment lines, and surface "oil" flow patterns that were
extracted from a 10-gigabyte dataset, without human intervention.

SC97 Booth Demonstrations

Images of Earth and Space: SC97 Edition



Goddard Space Flight Center (GSFC) presents a videotape that takes viewers on an electronic voyage through the Solar System and outer space. Scientific visualizations from GSFC, Jet Propulsion Laboratory, and the HPCC Earth and Space Sciences Project are depicted in graphical form. First stop is the Sun's interior to study turbulent processes that fuel observed solar activity. A long layover on Earth begins with an expedition over the solid surface and through the underlying mantle. Next, the warm waters of the 1997 El Niño invade the Eastern Pacific, while narrow currents flow through the Northern Atlantic. Ocean life worldwide is then traced with the latest satellite data. Jumping to the atmosphere, spectators attend a hurricane parade above the Atlantic and watch the waves and spirals of methane around the globe. A jaunt to Mars explores the mountains and trenches of its dry, rocky exterior. The journey concludes at a binary neutron star system, where two city-sized objects with the Sun's mass merge in a titanic explosion.

Microwave Optics Design Software

Many of Jet Propulsion Laboratory's (JPL) NASA missions use a microwave optics instrument to gather scientific data. JPL's High Performance Computing Group, in cooperation with the MIRO project, is using distributed and high-performance computing to reduce the amount of time needed to design and analyze such instruments. Many independent software packages are used in this design and analysis process, but JPL is in the process of integrating a number of these

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packages into a distributed environment, porting some of them to high-performance, parallel platforms.

The overall set of distributed software, called MOD Tool (Microwave Optics Design Tool), will be demonstrated. MOD Tool integrates existing microwave and optics analysis software with a solid CAD modeler and structural and thermal tools, with the goals of speeding up the development process for new instruments and improving the final instruments by allowing more design iterations.

Metacenter Software

The NASA Metacenter is a joint exploratory project between the parallel systems groups at Ames and Langley Research Centers. This fall, the Metacenter is expanding to include Lewis Research Center. The focus of the project is to achieve more effective use of NASA supercomputers by making the systems more easily available to researchers, and by providing quicker turnaround for batch jobs, a larger range of available resources for computation, and a better distribution of the computational workload across multiple supercomputers.

The "glue" that holds the Metacenter together is the Portable Batch System (PBS), a job management system. The designers of PBS recognized that the job scheduler is the most site-specific part of a batch queuing system, because the scheduler implements local policy. Writing a "peer-scheduler" as the external scheduler enables jobs to run on any system in the Metacenter. In addition, a significant amount of administration has been streamlined, including account maintenance, system and job accounting, and project allocations.

Multidisciplinary Design Optimization

For the first time, multidisciplinary design optimization (MDO) methods are available for large, complex aircraft. At NASA's Langley Research Center, the Framework for Interdisciplinary Design Optimization (FIDO) system allows interdisciplinary coupling between computational fluid dynamics and finite element structural analysis codes. A Langley video presentation will show how FIDO uses parallel and distributed computing to enable timely execution of complex codes, and simultaneous calculation of many interdisciplinary sensitivities. The demonstration will show how the system distributes the design process over a network of computers, controlling the entire process by advanced optimization methods.

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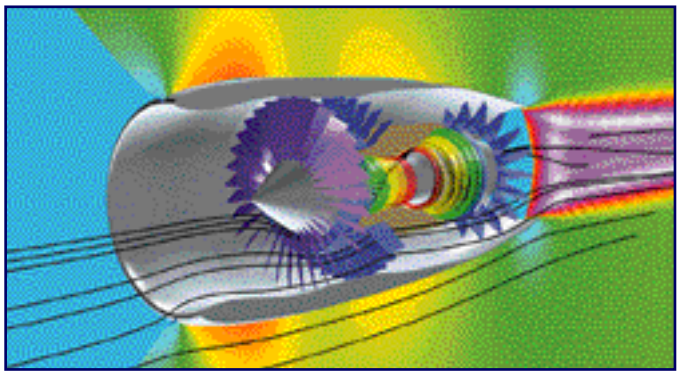
Additional research will allow visualization of various analyses conducted during the design process. Examples of these visualization methods are shown in an impressive gallery of images generated by the Parallel Graphics Library, developed at Langley's Institute for Computer Applications in Science and Engineering.

Results From Engine Simulator 2.0

NASA Lewis Research Center uses state-of-the-art computational fluid dynamics techniques like the axisymmetric, aerodynamic, full-engine simulation Engine Simulator 2.0 software (ENG20), which can simulate and visualize a complete jet engine. The code is designed to incorporate an aircraft engine company's component codes, and include their results in the engine simulation. In this way, a component or system designer can simulate the result of a component design change on the entire engine system. These techniques will be used to make aircraft engines quieter, more affordable, and more environmentally friendly.



Complex Applications on Low-cost Clusters

Researchers at NASA Lewis Research Center have assembled an Intel Pentium Pro (P6) cluster to demonstrate a viable platform for running a compute-intensive computational fluid dynamics application at significantly reduced cost, compared to more traditional parallel platforms such as UNIX workstations and massively parallel machines. The P6 cluster consists of 16 200-megahertz Intel Pentium Pro processors.

The CORSAIR combustion code was selected as a representative application. CORSAIR is a Navier-Stokes flow solver based on an

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explicit four-stage Runge-Kutta scheme, using unstructured meshes. CORSAIR, normally run on networked workstations, was ported to the P6 cluster under both the Windows NT and Linux environments.

The code was run under the Linux environment with a standard test case that has approximately 116,000 computational elements. The performance results of the reacting flow test case were compared to results achieved with the same test case on the HPCC Program's IBM SP2. The results from both systems were nearly identical, demonstrating that the 16-node P6 platform yields good performance at a significantly lower cost, and that it can be a viable platform for medium-scale applications.

Satellite Links for High-Bandwith Communication

Lewis Research Center's Space Communications group is sponsoring high data-rate demonstrations, which link the SC97 show floor to Cleveland, OH using their Advanced Communications Technology Satellite (ACTS). This experiment will employ a 622-megabit networking path to exchange data across the country, using a combination of terrestrial- and ground-based network links. This geographically distributed experimental network will showcase applications requiring high bandwidth communications between distant locations.

ACTS provides for the development and flight test of high-risk, advanced communications satellite technology. Using advanced antenna beams and on-board switching and processing systems, ACTS is pioneering new initiatives in communications satellite technology.

Numerical Propulsion System Simulation Video

The NPSS program will show their video, "The Numerical Propulsion System Simulation (NPSS): A New World of Aircraft Engine Design." The video emphasizes the program's direct and indirect benefits to U.S. taxpayers, including reduction in the time and cost of designing and building aircraft engines, making U.S. engine companies more

competitive in the world market. The video highlights the work done at NPSS and shows some of the program's high-performance computing and communications technology, visualization tools, and aerodynamical computational tools.